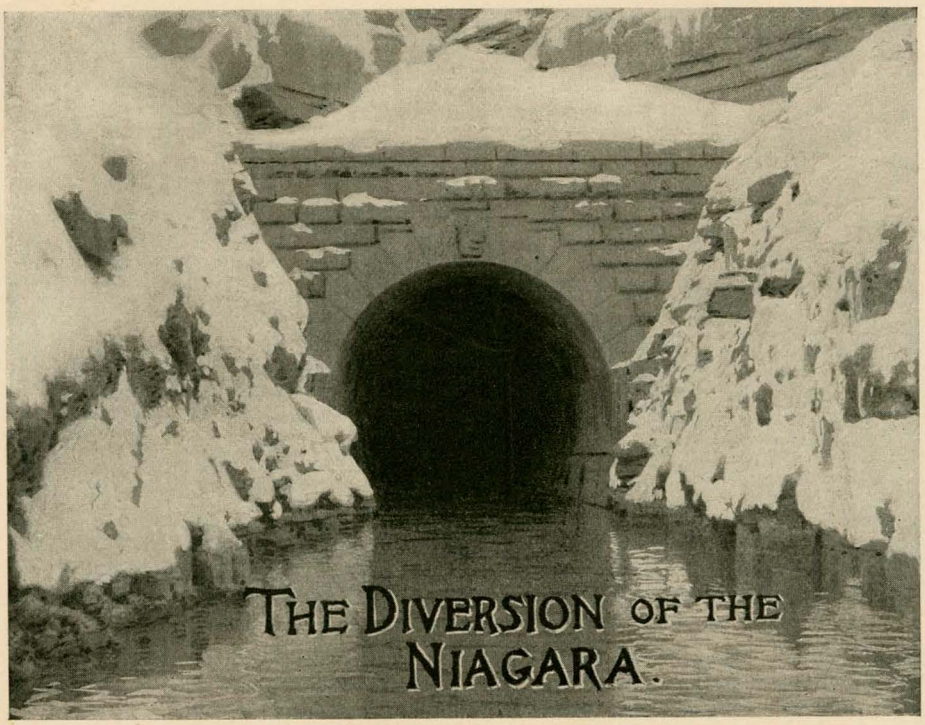


THE DIVERSION OF THE NIAGARA.

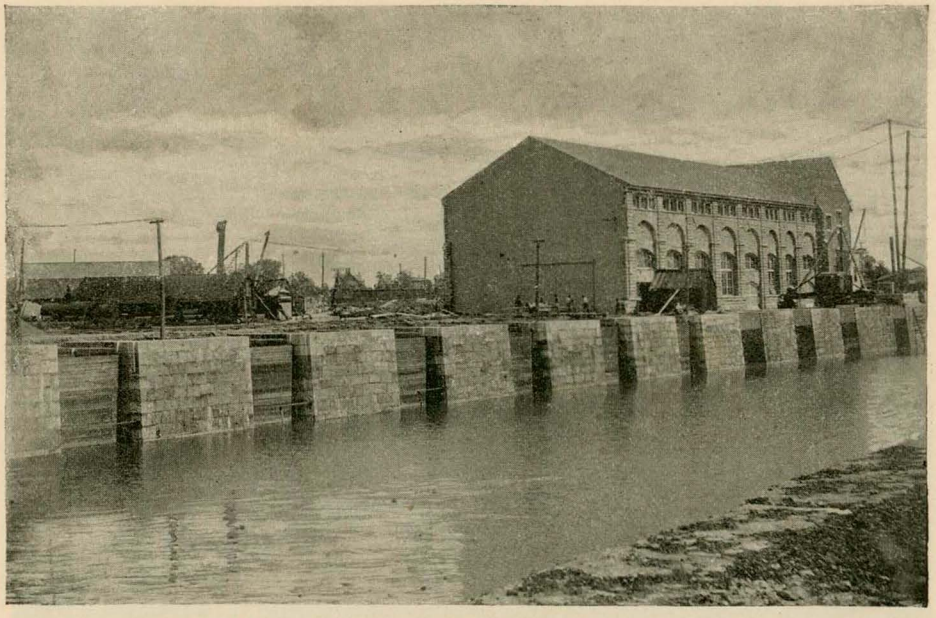
By Curtis Brown.

THE engineer who sees in Niagara Falls the greatest power-plant the Creator is known to have devised to do man's work, and the poet who thinks of the mighty cataract as one of the sublimest spectacles ever designed to lift man's soul, have each felt that the other's view, while doubtless worthy, was somewhat narrow. The poet has had his way about it chiefly, hitherto, and not all of the majesty of whirling rapids and overwhelming downpour have been made manifest. Now that the engineer has caught hold of part of this power, and has put his harness about it, Niagara gains new meaning and grandeur. It can turn ceaselessly the wheels of a thousand mills, without sign of labor or loss of beauty!

Tom Moore, who wrote the first Niagara poem of which history makes mention, visited the Falls in July, 1804, and recorded in his journal that his first full view of the cataract disappointed him. His fancy, aroused by a preliminary glimpse through the trees, had outrun the facts. "But," he writes, "in spite of the start thus got by imagination, the triumph of reality was, in the end, but

BLASTING IN THE HYDRAULIC CANAL.

Cosmopolitan Sept 1904



THE INLET CANAL, SHOWING GATEWAYS AND POWER-HOUSE.

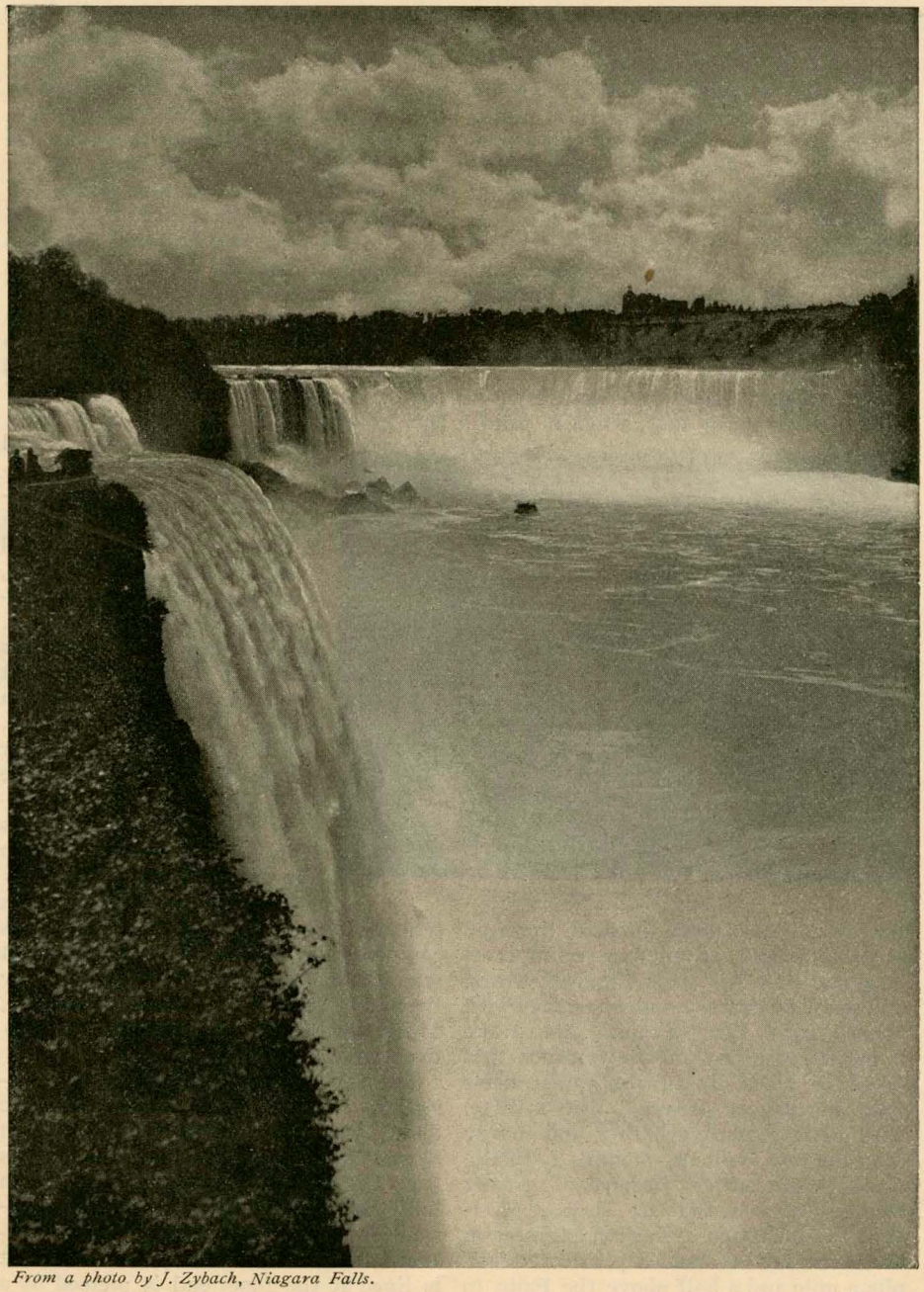
the greater; for the gradual glory of the scene that opened upon me soon took possession of my whole mind, presenting from day to day some new beauty or wonder, and, like all that is most sublime, in nature or art, awakening sad as well as elevating thoughts." The author of "Lalla Rookh" was moved to write verse of which the following is a fair example:

> "There, amid the island sedge,
> Just above the cataract's edge,
> Where the foot of living man
> Never trod since time began,
> Lone I sit at close of day," etc.

It is pretty poor stuff; but, with apologies to Joseph Rodman Drake, Mrs. Sigourney, and lesser poets, who have rhymed about Niagara, it is almost as good as any that has been produced on this subject. Perhaps the new dignity conferred upon the Niagara by the engineer will give future poets inspiration for better verse, and will help to dispel the feeling of disappointment that comes to almost every imaginative person at first view of the Falls. Poetry certainly lurks in the idea of an energy that can toss off lightly, without missing it, a far greater power than was ever before obtained from any one source.

Objection has been made to calling this work "the harnessing of the Niagara," for the title seems to imply an indignity to the majestic stream, as if it were being made a cart-horse of commerce, when, in truth, it might be said to be amusing itself by lending a small part of its strength to these labors—a diversion in a double sense. It is quite literally a figure of speech to say that the Niagara will "turn the wheels of a thousand mills;" but, unlike most figures of the sort, it will prove too small to represent the facts, if the plans for the utilization of Niagara Falls are fully realized. These plans provide for the ultimate development of power equal to nearly one-sixth of the entire amount in use in the United States in 1880, when the latest official estimate was made. It is the intention to distribute this power chiefly in the form of electricity, and the engineers have definite dreams of sending it even as far away as New York, Philadelphia, and Chicago, to be transformed into light, heat, and motive power.

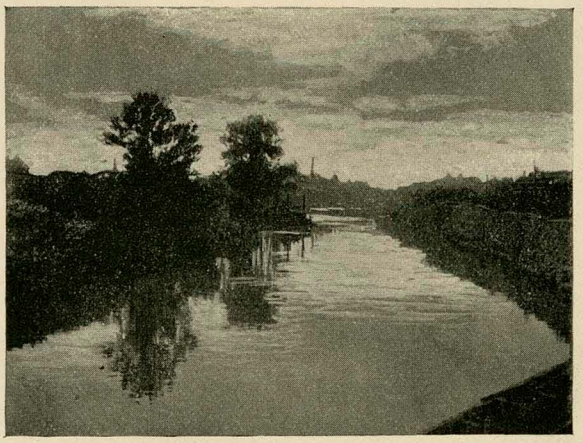
If the unprecedented dynamos, lately set in place, produce steadily the five thousand horse-power each which is expected of them, and if this power can be transmitted safely and economically to Buffalo, it is considered almost certain that Niagara Falls electricity presently will be doing much of the work of coal



From a photo by J. Zybach, Niagara Falls.

and natural gas throughout at least half of the State of New York. Time only will tell how much farther the cataract can be made to work economically, by proxy. But, whether or not electrical distribution of power fulfills its promises, the production of water-power, by means of the wheel-pits and tunnel lately completed at the Falls, has been proved feasible and economical. The largest paper-mill in the world has been obtaining its three thousand three hundred horse-power from the new plant since last January, and other mills and factories are being built, or are soon to be built, at Niagara Falls, to take the water-power now available.

The Niagara Falls were first used to turn machinery in 1725, when a primitive sawmill was built opposite the head of Goat Island, to cut lumber for Fort Niagara. In the next hundred years, and more, doubtless hundreds of men with a mechanical turn of mind laid awake o' nights, thinking of the fortunes that could be made by turning mill-wheels with this mighty stream. Two or three, with more executive ability and energy than the rest, built the present hydraulic canal, while others dreamed of greater things. In 1885, the late Thomas Evershed, of Rochester, a division engineer on the Erie canal, evolved a plan for wheel-pits a mile and a half above the Falls, to which water would be carried by lateral canals, and from which it would be taken to the river below the Falls by a tunnel. This plan was more practicable than any previously put forward, and it attracted the attention of many engineers, who discussed it earnestly, and who might have been wondering to this day if something could not be done about it, had not a brisk young New York lawyer taken hold of the idea in a different way, six years ago.

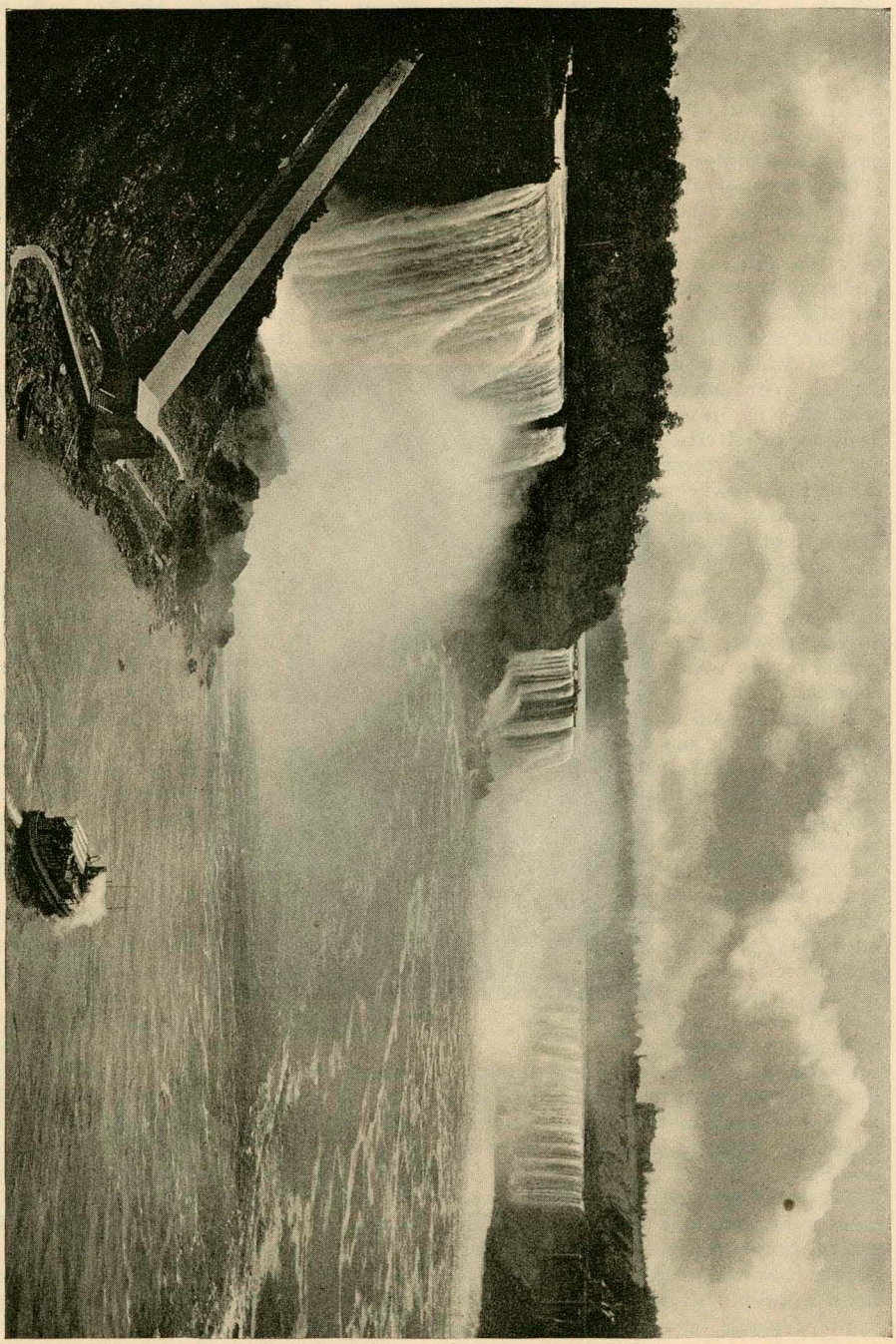


A GLIMPSE OF THE CANAL.

The Niagara Falls Power Company had been organized, and had obtained a charter from the legislature, in 1886, giving permission to use Niagara river water sufficient to generate two hundred thousand horse-power, but no local capital was available for development. Instead of further dreaming, New York capitalists and banking-houses were interested to the extent of many millions of dollars, and the services of the greatest engineers of this country and Europe were secured. Sir William Thomson, Colonel Theodore Turrettini, of Geneva, Switzerland, Professor Unwin, of London, Dr. Coleman Sellers, of Philadelphia, and Professor Mascart, of Paris, were designated as an International Niagara Commission, to invite the leading specialists to submit plans for the most economical use of Niagara power. Dr. Coleman Sellers, Mr. Clemens Herschel, Major George B. Burbank, and the Hon. John Bogart had the benefit of a study of the ideas thus obtained, and then agreed upon the plans finally adopted.

The first spadeful of earth was dug in October, 1890. The tunnel was completed last fall, and the main wheel-pit was practically ready for its machinery by the first of last March. The work has cost, so far, some four million dollars, and also twenty-eight lives.

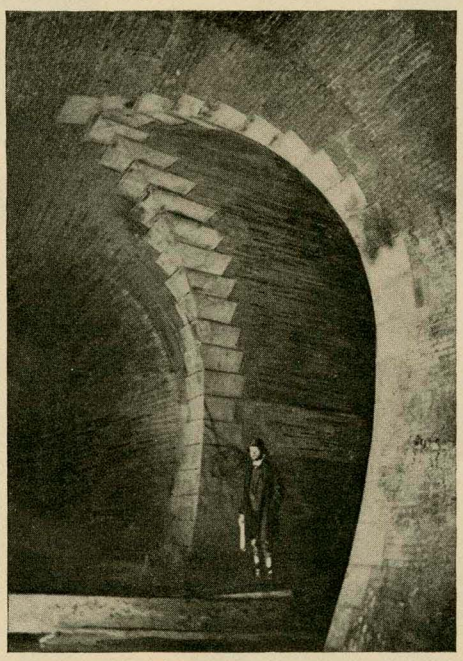
The device for applying a part of Niagara's strength to the wheels would be found to be simple, if one could see it on a small scale. A broad, deep inlet leads from the river, at a point a mile and a half above the American Fall, two thousand feet back in a northeasterly direction. The heavy masonry with which it is lined at the upper end is pierced by a score of gateways, through which the inflowing water will be admitted, by short canals, to pits, pouring down through huge steel pipes—the engineers call them



From a photo by J. Zybach, Niagara Falls.

"penstocks" — into the bronze turbine wheels at the bottom, and then whirling on through subterranean passageways that connect each pit with the main tunnel. This tunnel carries the water underneath the heart of the city to the portal, just below what is known as the new suspension bridge.

Only two of the score, or more, of wheel-pits have been dug at this time; but one of these is of more interest than all of the others can be, for it is there that power is to be created for electrical distribution. The others will be much smaller, and will be used for the production of water-power for local consumers, without the intervention of electricity. One of these smaller pits has been in operation since the 25th of January, and is soon to be the source of six thousand six hundred horse-power, generated by six water-wheels.



THE ARCH AT THE JUNCTION OF THE TUNNEL AND THE PASSAGEWAY FROM THE MAIN WHEEL-PIT.

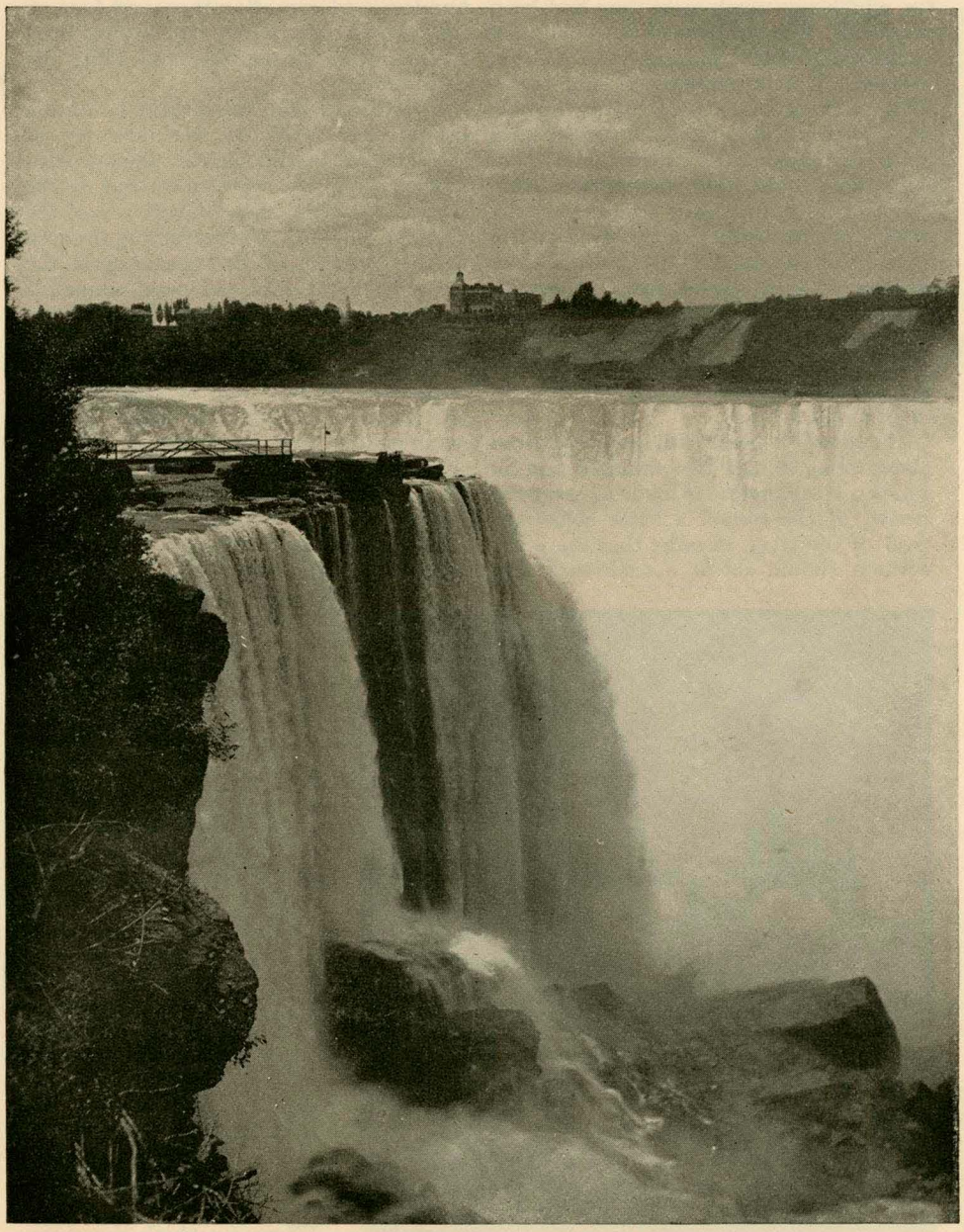
It may be said in passing that the satisfactory operation of the turbines in this pit, although it attracted no particular attention at the time, demonstrated the success of the engineers' plans for power-production in all the other pits; proved the ability of unprecedented vertical wheels to cope with and subdue a greater power than ever before had been applied to such machinery, and marked a distinct advance in the science of hydraulics.

The same species of wheel—but somewhat more than four times as powerful as any other turbines that were ever built—are made to revolve near the bottom of the main wheel-pit by the pressure of a column of water in a penstock seven feet in diameter and one hundred and forty feet high, each wheel generating five thousand horse-power, which is sent to the dynamos in the power-house above by means of steel shafts parallel with the penstocks.

The penstocks are brought down under the turbines and made to discharge upwards into the wheels, an ingenious contrivance by which the pressure of the water is made to bear up the entire weight of the heavy wheels and the one hundred and forty feet of shafting.

Three of these turbines are to be used at first, each having its own gateway, penstock, shaft, and dynamo, and forming practically an independent plant, which is expected to catch five thousand horse-power from the waterfall, and change it to electricity. If the current can be delivered by wire as economically as has been supposed, then the wheel-pit will be extended in a southerly direction toward the river, the intention being that eventually it shall hold ten turbines, producing fifty thousand horse-power. At present it is one hundred and seventy-eight feet deep, twenty-one feet wide, and one hundred and forty feet long.

In addition to the fifty thousand horse-power transformed into electricity at the central power-station, it is arranged that about fifty thousand more shall be developed in the various smaller pits, for direct use in adjoining mills and factories. The tunnel which will carry away the water used in developing this one hundred thousand horse-power is somewhat more than a mile and a quarter long, and twenty-one feet high, and is shaped like a horseshoe, being about fourteen feet wide at the bottom, and eighteen feet at the broadest part. It was cut in a straight line through rock, at an average distance of nearly two hundred feet underneath the city of Niagara Falls, emerg-

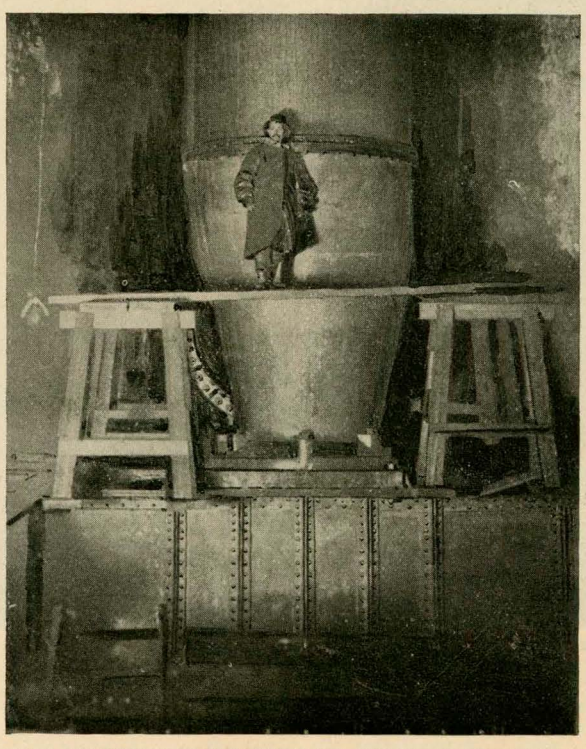


From a photo by J. Zybach, Niagara Falls.

ing at the bottom of the gorge, a short distance down the river from the American Fall. It cost about a million and a quarter, which was much more than had been expected. The softness of the shale rock encountered in several places was to blame for this. It kept chipping off, and crumbling, making it necessary to line the tunnel with from four to six layers of hard brick throughout its entire length, an item that would have staggered a company of less financial strength. The mouth of the tunnel is nearly fifty feet lower than the head, and the water tears through it at a furious rate. A marked piece of wood which was dropped in the water near the head of the tunnel recently, was whisked out at the portal, six thousand seven hundred feet distant, exactly three minutes later.

The tunnel is lined with heavy cast-iron plates along its last two hundred feet, in which a steep incline is made to carry the mouth of the tunnel a little below the level of the river, in order that the water without should act as a cushion to the water pouring down from within. Oddly enough, many acres of valuable real estate were dug from the tunnel, the three hundred and forty-five thousand tons of rock which was taken out having been used to build up marshy land along the river bank.

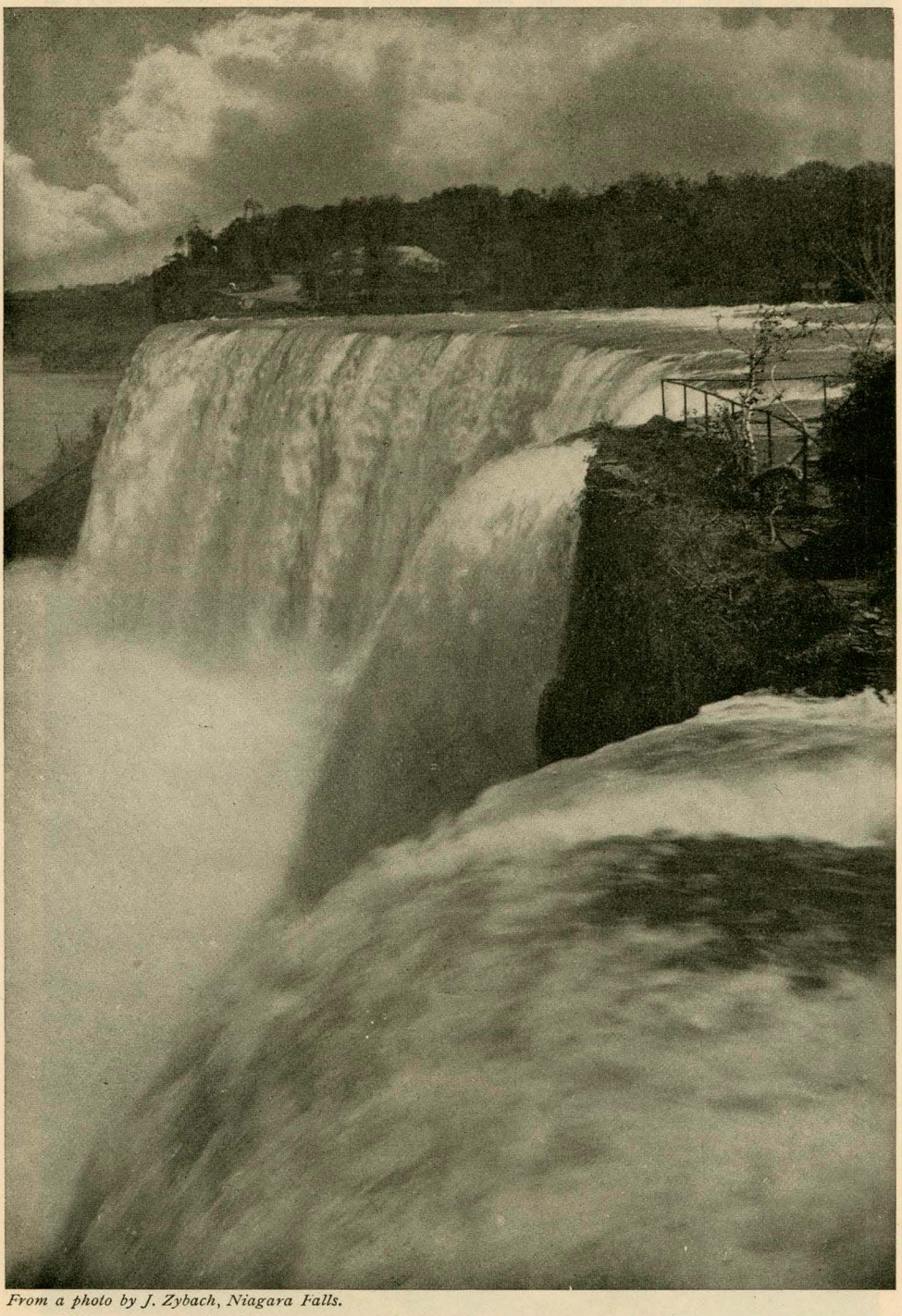
A feature of this, the largest hydraulic tunnel ever built, is the masonry at the entrance of the smaller passageways leading from the wheel-pits, and at the portal. A little thought will reveal the extreme difficulty of constructing the arch at the junction of the tunnel from the large wheel-pit with the main tunnel, a part of which is illustrated on page 532. The smaller passageway enters the larger at an angle of sixty degrees. Both are horseshoe-shaped, and, in consequence, the two faces and the outer angle of each stone in the arch have each a different curve, which required a complicated problem in mathematics to determine, and skilful cutting to produce in stone. The portal, extending down to a solid bed of sandstone, forty feet below the level of the river, is said to be one of the most solid pieces of masonry ever built.



NEAR THE BOTTOM OF THE WHEEL-PIT, LOWER END OF PENSTOCK OPENING INTO TURBINE AT THE REAR.

Like so much else connected with this enterprise, the three dynamos which were put in place in the central power-station within the past few weeks, are far and away the most powerful ever constructed, each being expected to transform the five thousand horse-power received from its turbine shaft into an equivalent of electrical force. The most ambitious dynamos heretofore constructed sent out a little more than two thousand horse-power, although a vain attempt was made once before at Deptford, England, to build a dynamo that would develop ten thousand horse-power.

Wires, for which the right of way has already been obtained, will be strung overhead to Buffalo, and by the last of October a contract to supply the city with ten thou-



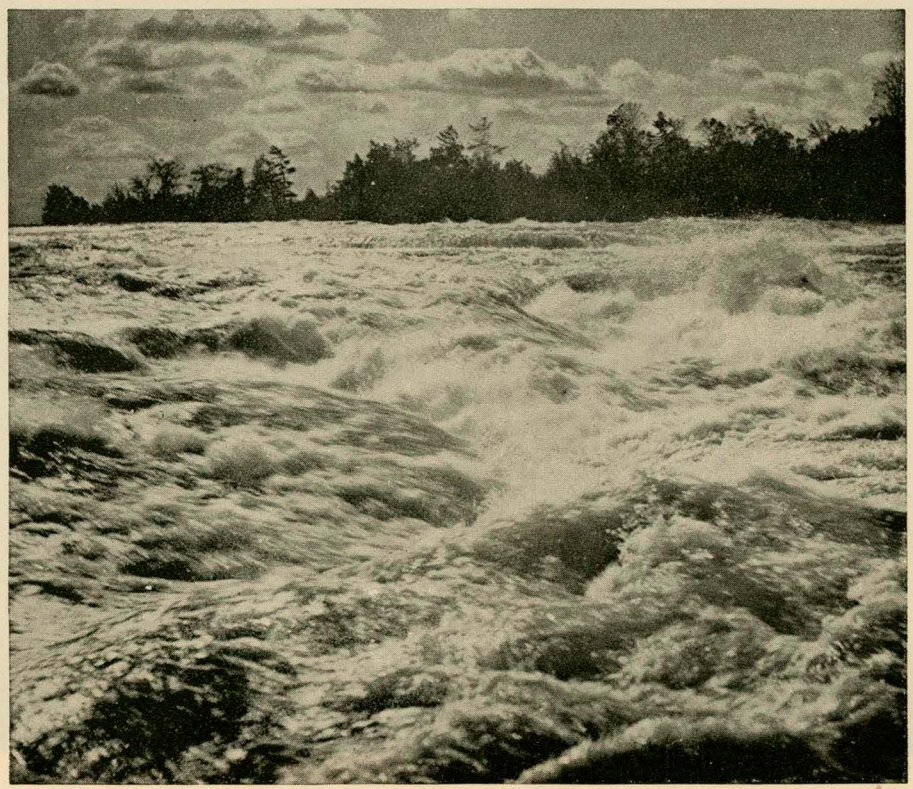
From a photo by J. Zybach, Niagara Falls.

sand horse-power, to begin with, and which it is hoped to increase indefinitely in the near future, will be fulfilled from the total of fifteen thousand produced by the three dynamos.

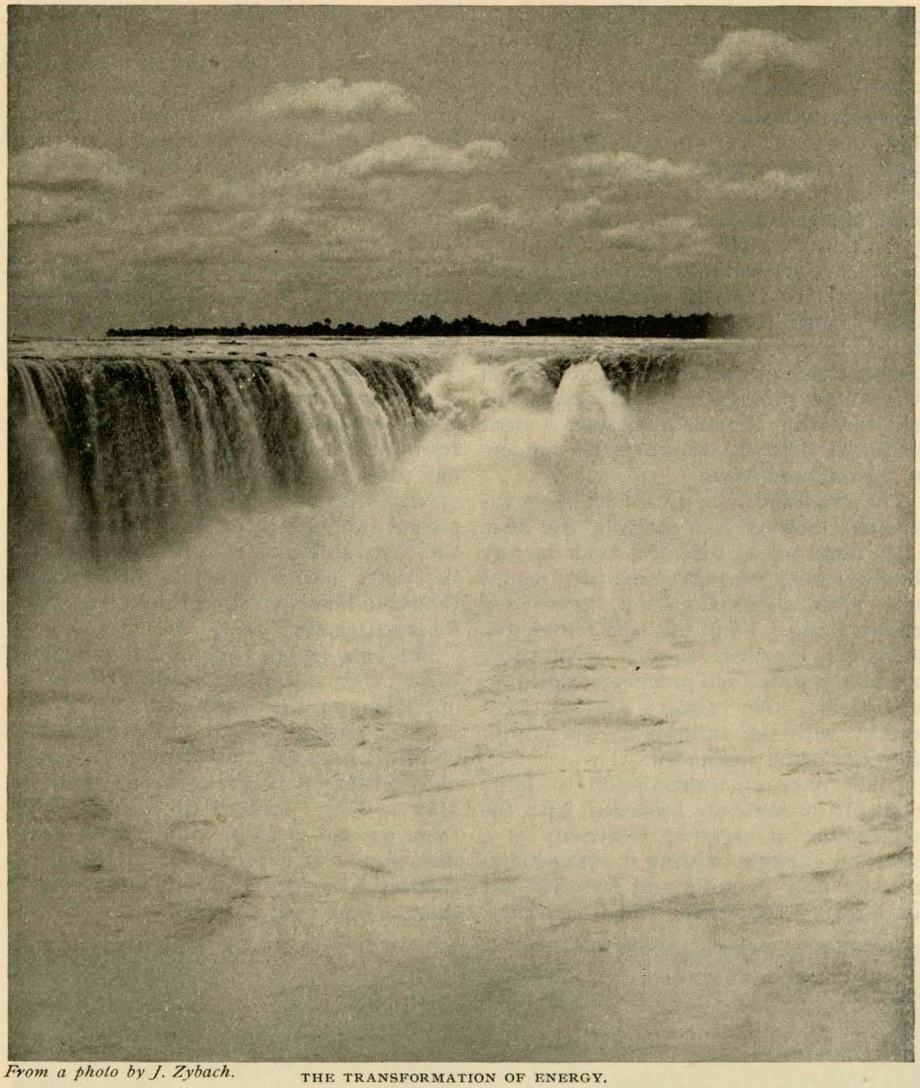
It is not an exaggeration to say that the first receipt of Niagara Falls power in Buffalo will mark an epoch in the history of the development of electricity. That moment will determine, approximately, how far great currents of electricity can be carried by the latest methods, without a loss from the wires sufficient to make the cost of the current equal the cost of steam-power. Upon this test depends largely the question whether Niagara power shall be sent broadcast through half a dozen states, or whether it shall be confined to western New York, and the result will be looked forward to with anxious expectation.

The answer to the question is not wholly in doubt, however. The largest amount of power heretofore transmitted by wire is three thousand horse-power, by which the city of Rome (Italy) is lighted with electricity generated from the graceful cascades at Tivoli, seventeen miles distant. The system of transmission used there is that selected to carry the Falls current to Buffalo, and as it has been in operation two years, without accident or interruption, it is a trustworthy promise of the successful conveyance of a much greater current, and to a greater distance. The iron columns of the Roman line are from one hundred and fifteen to one hundred and thirty feet apart, and carry the wires on porcelain insulators about four inches high, which project much like inverted lilies-of-the-valley from a stalk. The insulators consist of two parts, the lower being a cup filled with oil, in which the upper part rests. The copper line is bare.

As soon as it is demonstrated that power can be sent economically to Buffalo, the plant will be enlarged at once to supply Rochester, Syracuse, Utica, and Albany, where distributing companies already



From a photo by J. Zybach. THE SOURCE OF THE ENERGY.



From a photo by J. Zybach. THE TRANSFORMATION OF ENERGY.

have contracts for power, containing, however, a provision that the demand in these cities must be sufficient to warrant the cost of the installation. It is estimated that this initial demand must be for at least ten thousand horse-power in each city. New York State's Superintendent of Public Works, also, has signed a most important contract with a company organized to distribute part of the power generated at Niagara Falls. By this contract the State gives permission to use, for fifty years, the narrow strip of State land along the Erie canal,—known as the "blue line," from the manner of its designation on the State maps,—for the transmission of electricity as far as Albany. The company is to construct a trolley line along the canal within three years, and agrees to tow boats at a charge of not more than twenty dollars per horse-power a season, which is variously estimated to be from ten to fifty per cent. less than the present cost of hauling boats along the canal.

Experiments are to be made with every practicable plan of canal-towing that has been presented. Many cities and towns

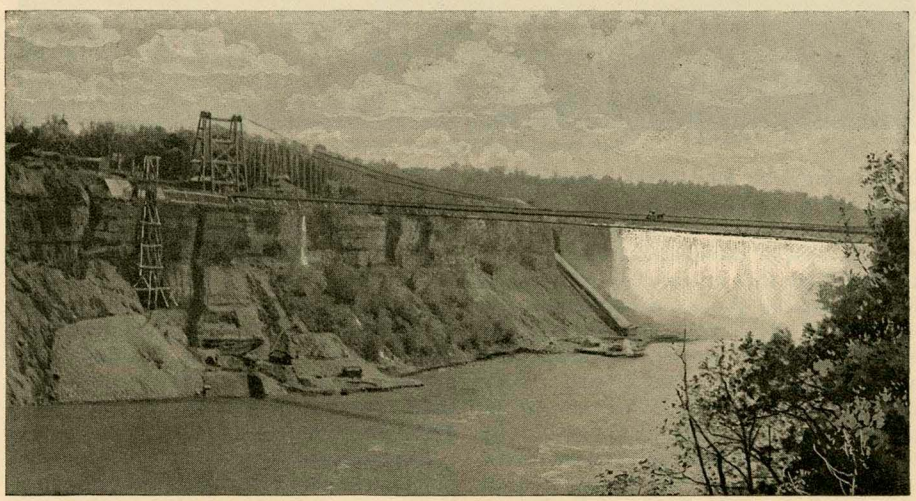
on or near the canal will be supplied, from the wires along the bank, with electricity for light, heat, and power. Governor Flower, of New York, is enthusiastic on the subject of canal-trolleys, and so is the Superintendent of Public Works, who says: "I have made a very close study of the proposed electrical distribution, and from assurances I get from the Cataract Company, which has in its employ the ablest electrical engineers in the world, I am satisfied that the electricity can be easily transmitted at least three hundred miles. In fact, I am confident that within the next five years these great electrical works now progressing at Niagara Falls will turn this Empire State into a great workshop that will be one of the wonders of the civilized world."

The canal-boatmen are much more interested, however, in getting the Erie canal deepened to nine feet than in any form of trolley-towing, which they regard with considerable suspicion, as an unknown thing. Fault has been found, too, because a franchise of such great value has been granted for practically nothing, a criticism that always carries great weight with the taxpayers, who think they are being defrauded.

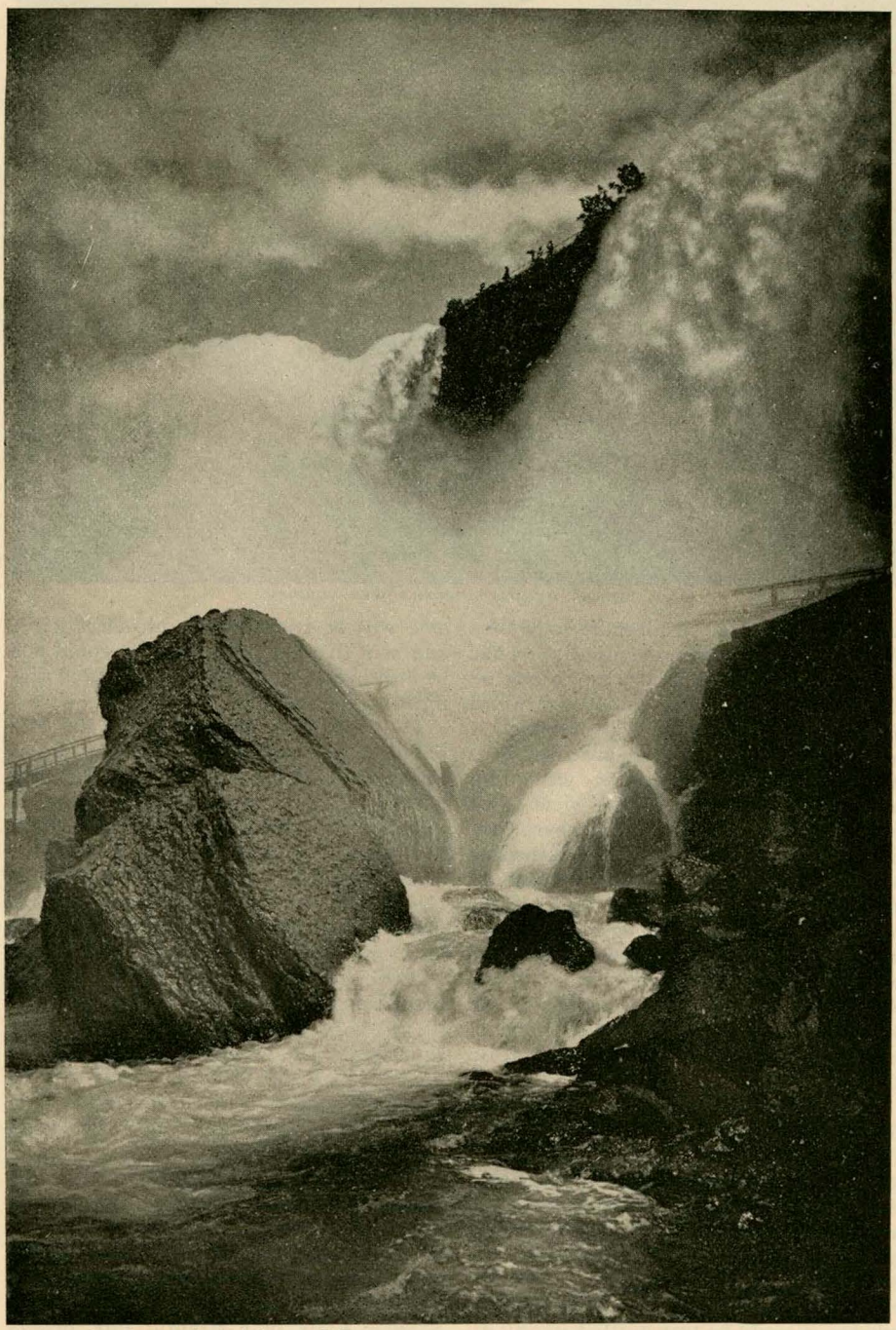
Other lines of transmission to large cities of the State are projected, with the expectation of carrying electricity at a price low enough to bring it into general use, not only in mills and factories, but for lighting the streets, and in cooking, lighting, and heating, in the houses of rich and poor alike. The electric light companies now established in most cities of the State will not be extinguished, but in all probability will take their electricity from the Falls current, instead of, as they now do, manufacturing it themselves, thus procuring their power at a cheaper rate, without having the bother of looking after it themselves.

These undertakings, together with the requirement of water-power for direct use at the mills which are springing up near the head of the tunnel at Niagara Falls, will exhaust the one hundred thousand horse-power capacity of the tunnel, and, if the demand for power continues, will result in the beginning of work on a second tunnel and wheel-pit, for which right of way already has been obtained. The second tunnel will be in all respects like the first, and like it, will accommodate the water used to generate one hundred thousand horse-power, with space to spare for emergencies.

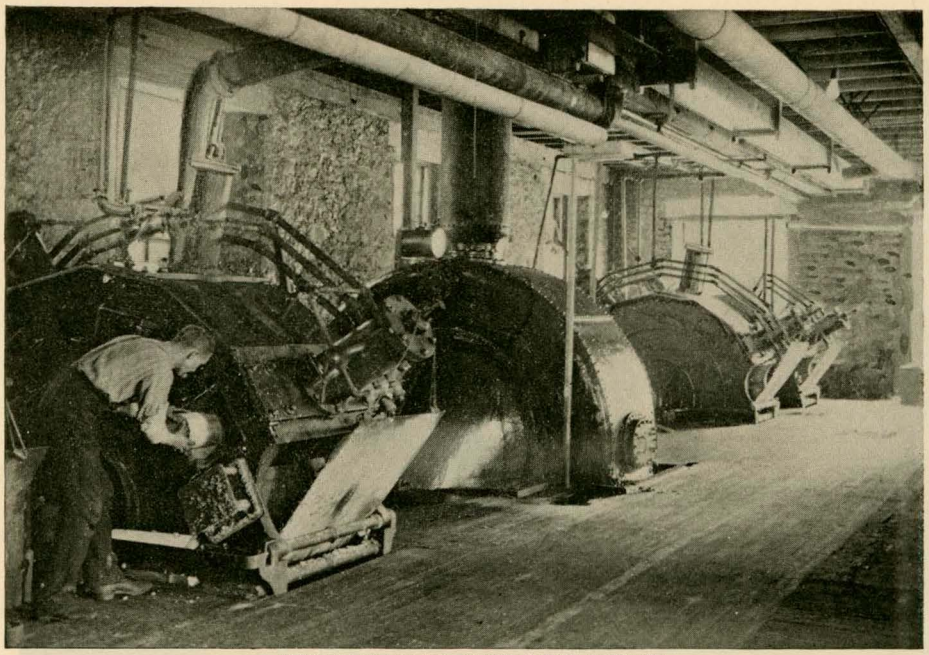
But long before this second tunnel is begun, a greater plant probably will be in operation on the Canadian side of the Falls. Permission to build this plant was obtained from the Canadian government on condition that the work be begun by May 1, 1897. Instead of waiting until then, ground is to be broken next summer, and it is expected that at least ten thousand horse-power will be developed there a year from this fall. It is the in-



PORTAL OF THE TUNNEL IN THE GORGE BELOW THE NEW BRIDGE.



From a photo by J Zybach, Niagara Falls.



A TWELVE HUNDRED HORSE-POWER TURBINE.

tention to generate two hundred and fifty thousand horse-power, eventually, on the Canadian side, and, according to one of the plans, there may be something weird and uncanny about the way in which it is to be done. This plan provides for a huge subterranean chamber extending out beneath the bed of the river, just back of the Horseshoe Falls, where they begin to thin out toward the Canadian shore. The chamber would contain all the turbines and dynamos, and all the other machinery for the development of water and electrical power, and there would be no sign, above ground, of the stupendous work going on below. It would form a vast laboratory for the manufacture of electrical power deep within the earth itself.

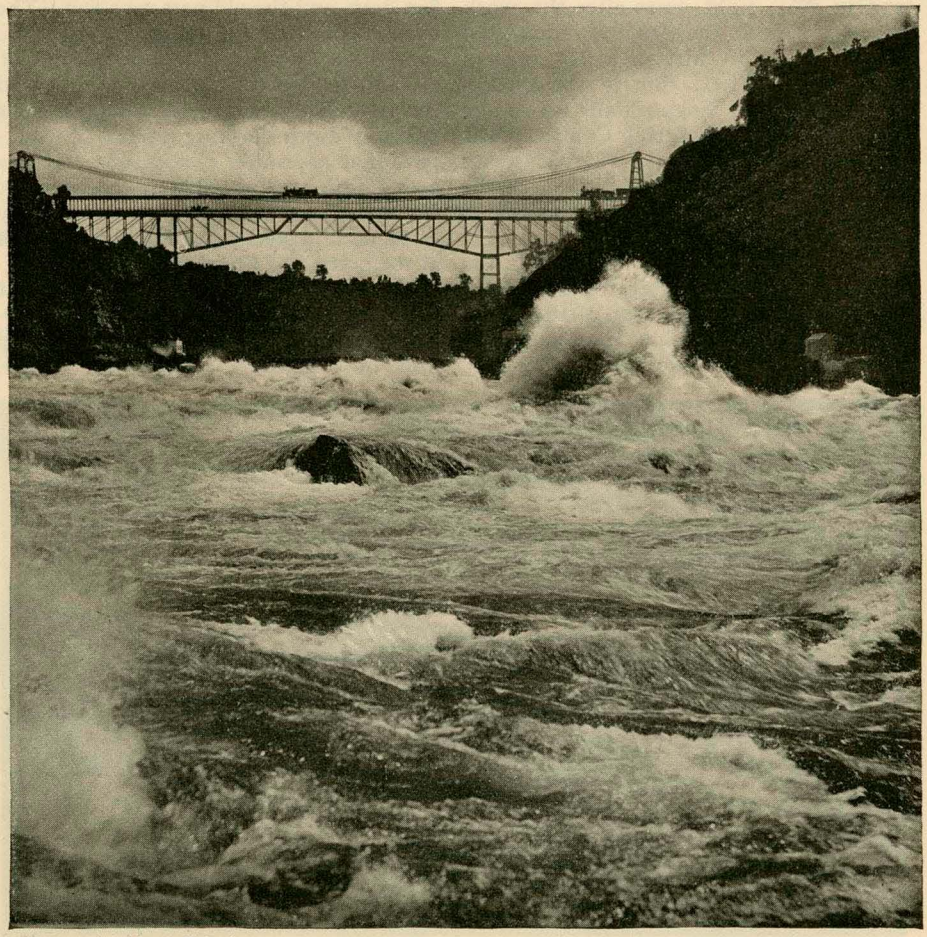
A series of inlet pipes would lead the water straight down from the river-bed to the water-wheels, discharging thence into a tunnel leading to the base of the Falls. Access to the cavern would be had from somewhere in Victoria Park, by means of elevators, or inclines, through which the electrical conductors would also lead the current from the dynamos to the surface, whence it could be transmitted in any direction and to any distance required. All of the power generated on the Canadian side will be transformed into electricity, and sent to a distance, as mills could not be built adjacent to the plant without disfiguring the scenery.

The element of uncertainty in the distribution of electricity is its elusiveness. Speaking untechnically, it leaks from the wires and the dynamos, and the further it is transmitted, the greater the loss. Power that can be sold at a profit at Niagara Falls for fifteen dollars a year per horse-power will, at a certain distance, reach a price equal to that of steam, owing to this loss, and to the expense of installation. Electricians are cautious about making predictions as to whether this distance is likely to be one hundred miles, or one thousand. Dr. Coleman Sellers, who is president of the Niagara Falls Power Company, and a most conservative, experienced, and careful engineer, writes as follows on the subject :

"It is absolutely certain, from what has already been done elsewhere, that profitable transmission to a distance of one hundred and fifty miles is only within the existing practice of distributed power. This one hundred and fifty miles from Niagara Falls, in a straight line, brings us to within ninety miles of the city of New York ; and if we assume as probable

economical transmission to a distance of three hundred and twenty miles, we have an area including the densest population, taking in Columbus (Ohio), touching Washington (District of Columbia), including Philadelphia, and New York, and the whole of the States of Pennsylvania, New York, part of Maryland, the northern part of Virginia and West Virginia, more than two-thirds of Ohio, fully three-quarters of Michigan, beside reaching to Montreal, in Canada, thus showing that the situation of Niagara Falls is phenomenal in its ability to distribute the power over an area that furnishes the most desirable market for profitable development. If, in the near future, Chicago can receive its power from Niagara Falls, then the whole of New England, with the exception of Maine, will come within reach of the Falls."

The two tunnels on the American side, and the power-plant on the Canadian side of the Falls, will have a total capacity of four hundred and fifty thousand horse-power. The significance of these figures will be better understood when it is called to mind that, according to the census of 1880, the total amount of water- and steam-power produced in the State of New York, at that time, was equivalent to four hundred and forty-three horse-power. In other words, the power to be derived from the plants already in contemplation will be equal to the whole power employed for manufacturing purposes in the great State of New York in 1880.



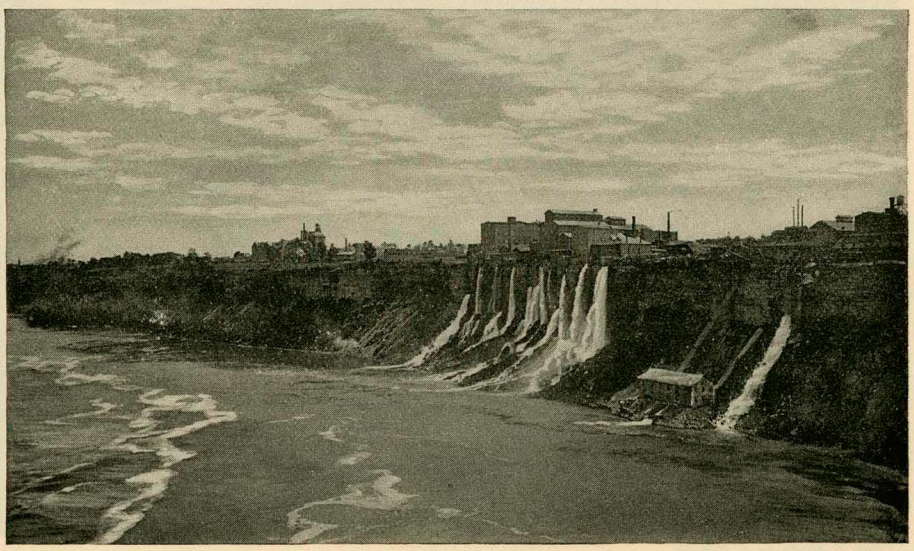
From a photo by J. Zybach. WASTED ENERGY.

In addition to this four hundred and fifty thousand horse-power, to be taken from the river by the corporation known as the Niagara Falls Power Company, a large amount of horse-power is to be produced by another company, by means of the hydraulic canal mentioned at the beginning of this article. For a time, until the development of the more remarkable work up the river, the corporation owning the hydraulic canal enjoyed the distinction of having the largest power-plant in existence. The plan for the canal was outlined, in 1847, by Mr. Augustus Porter, and the work was undertaken, in 1853, by ex-Mayor Caleb J. Woodhull, of New York, and Walter Bryant, of Massachusetts. After delays which exhausted two sets of contractors, a third took it up, and in 1861, eight years after the work was commenced, the canal was completed to the width of thirty-five feet, with a depth of eight feet. But it was not until 1875 that the Niagara Falls Hydraulic Power and Manufacturing Company was organized, and the canal was put to its best use, and became the pioneer of the great power plants now being constructed at the Falls.

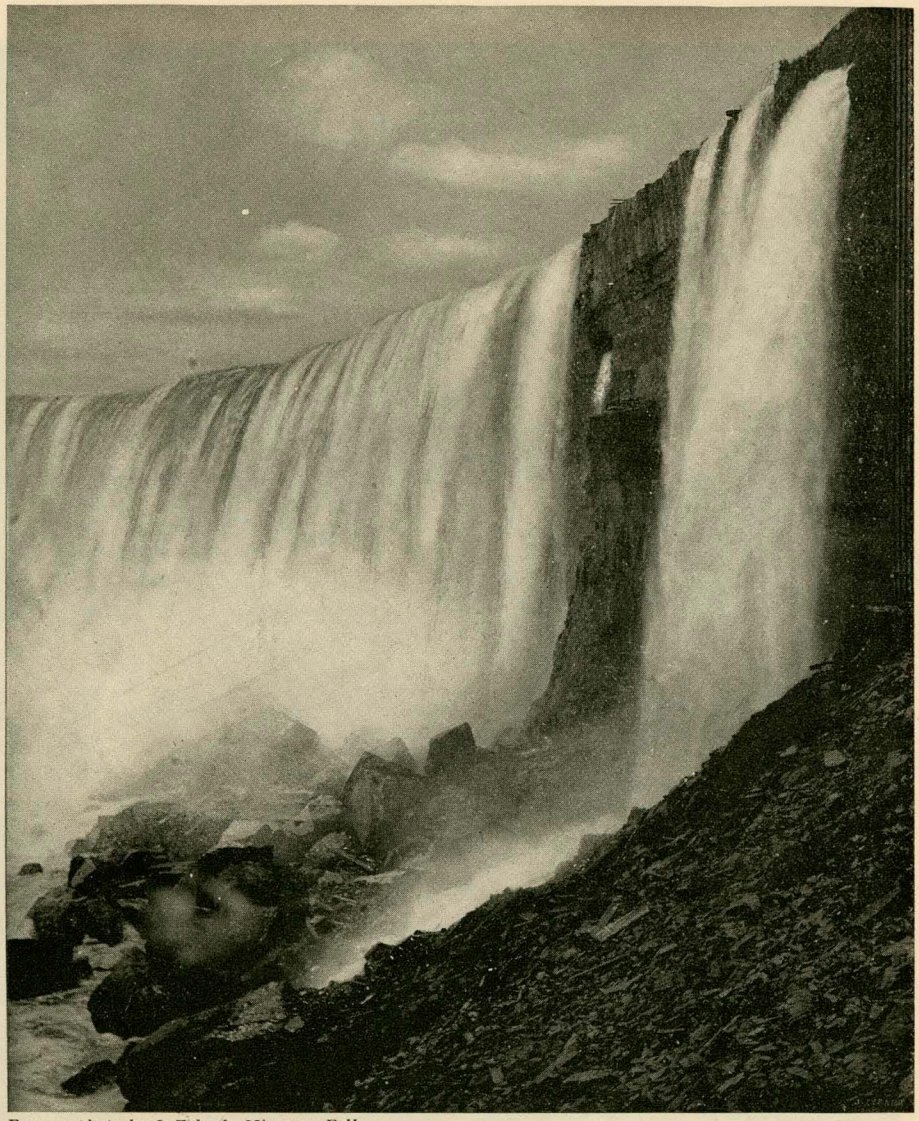
This hydraulic canal begins at the Niagara river, just before the last rapid descent is made to the head of the Falls, and some distance below the other company's tunnel. It runs through the city, and over the tunnel, to a basin near the high bluff a few hundred feet below the new suspension bridge. Here the water tumbles into wheel-pits, generating at present seven thousand five hundred horse-power for the large mills which mar the beauty of the gorge, half a mile below the American Fall. The canal has just been widened from thirty-five to seventy feet, by blasting through the rock. By the way, an intrepid photographer, sheltered somewhat by an overhanging bridge at Third street, obtained, at close range, the unique photograph reproduced at the beginning of this article, showing a blast of one hundred and seventy-five pounds of dynamite, which tore up one hundred yards of solid rock.

The new part of the canal is fourteen feet deep, and the old part nine feet. The water carried to the wheel-pits from the canal-basin escapes from the bottom of each, through short tunnels in the rock, to the river bank, whence it emerges about half-way down, forming a series of waterfalls that are rather picturesque. It has been found, however, that this waste water can be used economically a second time, by carrying it in steel pipes to turbine wheels at the bottom of the cliff.

This has been done successfully in at least one instance. Two horizontal turbines furnishing power for a wood-pulp mill, built recently at the river's edge,



THE DISCHARGE FROM THE HYDRAULIC CANAL.



From a photo by J. Zybach, Niagara Falls.

being operated under a head of one hundred and twenty-five feet, producing one thousand two hundred horse-power each. These, until they were eclipsed by their neighbors at the other end of the city, enjoyed the renown of developing more power than any other two water-wheels in the world.

The company operating the hydraulic canal charges from six to eight dollars a year per horse-power, which, all things considered, is about the same as the price to be paid by the other corporation's tenants up the river. The company has ambitious plans for the future, and expects to compete with its neighbor in electrical distribution. It has the right of way for a canal one hundred feet in width, and has made arrangements to enlarge its plant as soon as the demand for more power arises. It is now making a thorough test of electrical transmission with a one hundred

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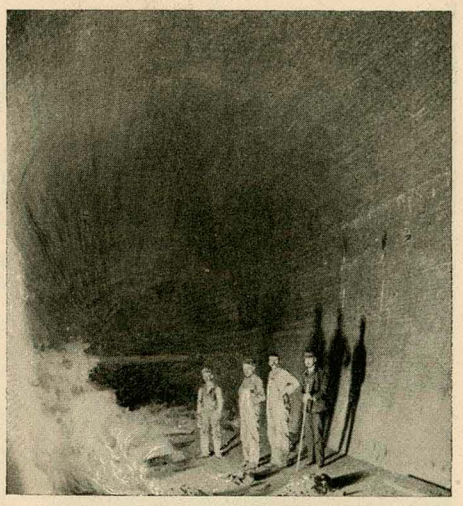
and twenty horse-power generator. Mills requiring less than five hundred horse-power, an amount too small to make exclusive use of a turbine worth while, will be supplied with electric power, and, if the enterprise of the greater power company on the other side of the city demonstrates the feasibility of sending tremendous electrical currents on long journeys by wire, the production of electrical power on a large scale, for transmission to Buffalo, and possibly to other cities, will be begun as soon as possible at the hydraulic canal basin.

After reading of the immense force, represented by hundreds of thousands of horse-power, that it is confidently expected will be drawn from the energy of the great cataract, and remembering that this power is procured by withdrawing water from the river above it, the reader might well ask: What is to become of this, the grandest spectacle on the continent? Is it to be sacrificed to the greed of gain, and the beauty of it lost in mere mechanical contrivances? And, too, the immense plants, are they to be allowed to mar the beauty of the surrounding country?

But no one visiting the Niagara Falls reservations when these great enterprises are fairly begun, or half a dozen years from now, when, perhaps, they will be fully developed, would find any outward and visible sign of them, except the mills along the hydraulic canal basin, which for years have formed a part of the view from Victoria Park.

There is little danger, also, to the Falls themselves. The vast mass of water speeding over the precipice will suffer but little diminution — three-quarters of a foot, perhaps, not more — in furnishing this immense force to the manufactories of the country. In 1890, the Hon.



IN THE MAIN TUNNEL.

John Bogart, then State Engineer and Surveyor of New York, in accordance with the request of the Niagara Falls commissioners, made a report in which he estimated that a tunnel having a capacity for discharge of water producing one hundred and twenty thousand horse-power would reduce the depth of the water at the crest of the American Fall about one inch and four-fifths, and the half a million horse-power called for by present plans of both companies will take about nine inches from the Niagara, reducing the average depth of water at the edge of the precipice from six and one-quarter feet to five and one-half feet, certainly not enough to make any noticeable difference in the appearance of the cataract, whose sources of power stretch half-way to the Pacific, and whose strength, ceaselessly put forth, is more than twice as great as the combined energy of every steam-engine in North America.